

3. Firm, adjustable support is obtained without resort to external incisions or insertion of foreign material into the maxillary sinus.

4. The splint may be allowed to remain in position for two to four weeks without causing discomfort or undue irritation until the callus is sufficiently strong to retain the fragments, when it may be easily removed.

5. In using the splint it is necessary that the patient should have several posterior maxillary teeth on the same side as the fractured zygoma, but this requirement is almost always fulfilled.

REFERENCES

1. GILLIES, H. D., KILNER, T. P. AND STONE, D.: Fractures of the malar-zygomatic compound; with a description of a new x-ray position, *Brit. J. Surg.*, 1927, 14: 651.
2. STRAITH, C. L.: The treatment of facial wounds due to motor accidents, *J. Mich. State Med. Soc.*, 1935.

THE CHOICE OF SKIN GRAFTS IN PLASTIC SURGERY

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WHEN a part of the body is lost there is a wide choice of both tissues and methods of grafting available for its reconstruction. Skin, cartilage, bone, nerve and fascia may be grafted with reasonable assurance of success and by a variety of procedures. Faced with a loss of tissue, one estimates its kind and amount, and plans by what tissue, and by what method, it will be restored.

The development of skin grafts has been interesting, and dramatic and many ingenious procedures have been devised. They are divided broadly into two main groups: (a) the free grafts, and (b) the pedicle grafts. Free grafts are those which are severed completely from their source of nourishment and depend for their existence on a capillary oozing of serum from the graft bed. This group includes the large thin and thick split grafts popularly known as Thiersch grafts, the small thin and thick split grafts spoken of as "pinch" grafts and the full thickness or "Wolfe" graft. It also includes the "grille"¹ and "sieve"² grafts recently introduced by various workers. The pedicle grafts are of greater bulk, and contain an amount of subcutaneous tissue and at no time are they separated from a carefully nursed blood supply. These are the pedicle grafts, delayed pedicle grafts, and tubed pedicle grafts.

In a study of skin grafts it is well to bear in mind the skin structure (Fig. 1). The epidermis with its squamous and basal-celled layer and papillæ, the cells of which are accustomed to receive their nourishment by capillary phenomena, contains no vessels. The derma or corium, on the other hand, contains blood vessels

and the accessory skin structures in a connective-tissue reticulum. Beneath are fat, fascia, and other subcutaneous structures. With this in mind it is understandable that the thinner the graft or the more confined to epidermal structures, the greater chance it has to live by free grafting. The cells are used to living by capillary phenomena and may well do so on transfer to a slightly altered site. On the other hand the thicker grafts, containing greater amounts of derma, are more highly specialized and used to an organized blood supply, and so the thicker the graft, the more precarious it is from the standpoint of free grafting. When more than epidermis and derma are used, it becomes necessary to use the pedicle type of graft.

The *thin split skin graft*.—This is commonly known as the Thiersch or Ollier-Thiersch graft, or thin razor graft. Blair and Brown³ introduced the terms thin and thick split skin grafts which are descriptive of splitting away the skin with a razor or knife parallel to the surface at various depths. The thin split graft aims to take away the epidermis in a tissue-paper-like sheet with little or no derma (a in Fig. 1). The donor site bleeds only in fine punctate points and heals rapidly and completely. It has a high percentage of takes and is useful in infected areas, but it is rather poor in appearance and may be glazed and shiny with no accessory skin structures. It tends to shrink and is useless where there is deep loss of tissue and scar contracture or on areas that must bear any pressure. Its greatest use is in lining mucous cavities such as the eye socket or mouth, where it seems to take on the characteristics of mucous membrane. It is cut and wrapped around a mould or stent of dental

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impression compound and sewn into the cavity to be grafted. It is most useful for enlarging stenosed eye-sockets or removing adhesions and establishing fornices in the mouth.

The *thick split skin graft* includes the epidermis with from one- to two-thirds of the derma. It splits the derma through its lower levels, leaving a small amount from which regeneration takes place and providing a tangible graft of reasonable thickness with a suitable cushion of corium carrying some accessory skin structures (b in Fig. 1). This is the most widely used free graft and has a high percentage of takes. As one becomes more accustomed to its use, the indication for the thin and small types of skin grafts disappears. The donor site regenerates quickly from the sides and bases of hair follicles and is usually completely covered in ten days and successive crops of grafts can be taken from it at not too long intervals. Brown⁴ reports as many as four crops of grafts from one donor site. The graft itself is cosmetically good, velvety, of a reasonable thickness and may grow some accessory skin structures.

This graft finds its greatest use in resurfacing the skin losses as in burns, and there seems to be a tendency in burn treatment toward their early surfacing to get away from the prolonged tannic acid eschar, to promote early granulation and skin grafting, thereby limiting the period of disability and lessening those horrible scar contractures and keloids. It is also useful in replacing scars, grafting chronic ulcer sites, and resurfacing operative areas as in radical breast amputation. One excellent use it has been put to is in resurfacing the skin of the penis after denudation from various causes. Brown⁵ reports four most interesting cases with very satisfactory results.

The judgment, skill, and excellent teamwork of Blair, Brown and Byars,^{5, 6, 7, 8} of St. Louis, has been largely responsible for the development of these thick split razor grafts. A combination of preparation of the bed, cutting and placing of the graft and secure dressing, each play about an equal part in their excellent results. The bed is carefully nursed along with saline baths and dressings alternating with dry treatment until a healthy mat of firm granulating tissue covers the area. This is shaved down to a firm yellowish bed and the grafts are cut with a Blair knife and suction technique, placed

on the donor site, and "basted" in position with running horsehair or silk sutures. Stab wounds are made to allow exit of blood or serum, and then a dressing carefully built up with layers of xeroform gauze topped by sea sponge to provide a continuous, snug, pressure dressing. Large grafts, 3 to 4 inches in width and 8 to 10 inches in length, can be cut. After watching this team of experts work and graft the whole circumference of a thigh from the skin of the abdomen at one operation and seeing a 90 to 100 per cent take one is impressed by the efficacy of the method and the indications for the other types of free graft and even the tubed pedicle rapidly narrow.

Recently, Padgett,⁹ in an effort to standardize skin-graft cutting, brought out the "dermatome", a machine for cutting calibrated grafts. This consists of a knife set at an adjustable distance from a drum. The drum and skin to be cut are coated with an adhesive which sticks the skin to the drum, the knife cutting it at the required thickness. The machine and technique are a definite advance and will find a welcome in plastic surgery. However, they are not a "cure-all", for the difficulties of graft cutting and require careful study and mastering.

The small grafts.—Reverdin, in 1869, advocated a graft in which the epidermis was pinched up with forceps and a small piece a few millimeters in diameter cut off. Many such pieces were cut off and impaled in the granulating bed to be grafted, the principle being that epithelium would grow out from these islands and soon effect a covering of the area. This has come to be known as "the pinch graft", which term is not quite correct as the pinching and cutting with scissors is too traumatizing and is no longer used. It is picked up on a needle and sliced away with a knife or razor down to almost the full depth of the corium at its centre and impaled in the granulating bed where the whole bed with its multiple little grafts is carefully dressed. Cosmetically, it is a poor graft, as both donor area and graft are unsightly, with numerous humps and hollows. It is slower in healing than the thick split grafts. The small grafts take reasonably well in infected areas and its greatest usefulness lies in starting epithelialization in small children or debilitated persons in whom large donor sites are not available. Yet,

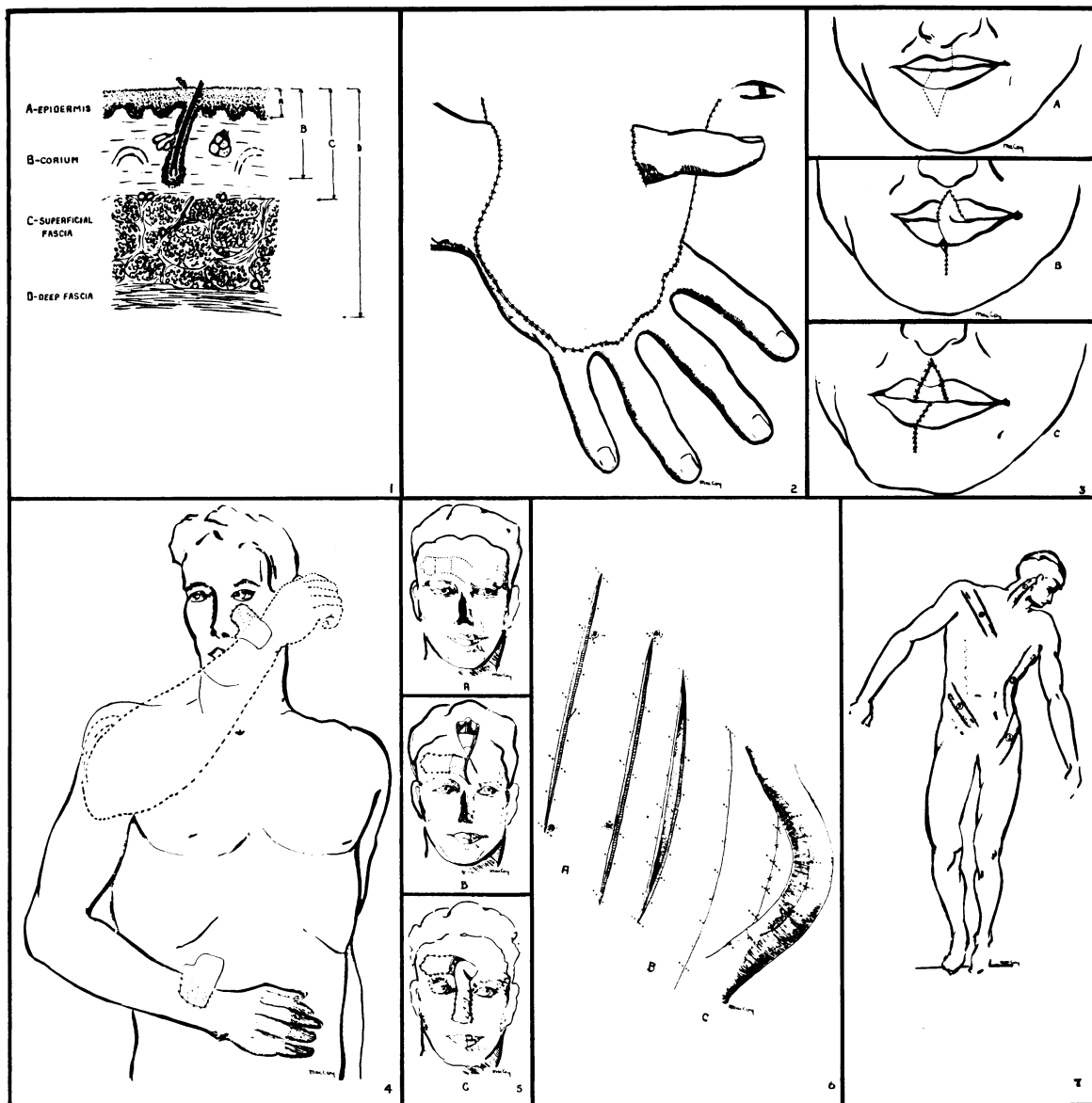


Fig. 1.—Diagram of the composition of the various grafts. (a) The thin split graft is made up of epidermis with a very small amount of derma or corium. (b) The thick split graft cuts away epidermis plus most of the corium. (c) The full thickness or Wolfe graft takes epidermis and corium *in toto*. (d) The pedicle and tubed pedicle grafts mobilize all three layers, epidermis, corium, and superficial fascia, with more or less, preferably less, of its contained fat. **Fig. 2.**—Diagram of the possibilities of a direct pedicle flap. The flap is raised from the abdomen and sewn directly into a defect on the dorsum of the hand. If the operator feels the project is too ambitious for a direct flap it is better delayed for ten days, *i.e.*, raised and sewn back into the same position on the abdomen and after a ten-days' interval raised again and sewn into the hand defect. **Fig. 3.**—The Abbé lip switch operation is an example of a simple pedicle flap. (a) It is cut on the lower lip using the inferior labial artery on the left side for nourishment, and (b) rotated about and set into a cut in the deficient upper lip. (c) At the end of ten days the pedicle is cut and the lips adjusted. **Fig. 4.**—The delayed pedicle flap has wide applications without tubing. Diagram to show how one-half may be set into the wrist, the other half delayed on the abdomen for a stage and then set into a defect on the face. **Fig. 5.**—The classical nose reconstruction operation is of the delayed pedicle type. (a) The flap is cut on the forehead to careful measurement and sewn back in position. A split skin graft may be placed underneath as between the vertical dotted lines to provide lining for the nose. (b) The flap is raised and the ends turned in to form the columella and alæ, and (c) sewn into position on the nasal defect. A split skin graft is used to fill in the distal forehead defect. **Fig. 6.**—Raising a tubed pedicle flap. (a) The incisions are to be staggered and are marked out with a series of double and single dots. Point A is to go to point A1, B to B1, and so on, double dots to double dots and single to single, both on the tube and on the donor site. (b) The incisions are made down through the superficial and sometimes the deep fascia and the flap raised, and (c) the flap is tubed. **Fig. 7.**—Some common sites of tubed pedicle flaps. See text.

as one's ability for cutting and placing large split grafts grows the indication for this small type of graft disappears.

The *full thickness graft* (Wolfe, Wolfe-Krause) is excellent in certain well-defined indications. Cosmetically, it is the most satisfactory free graft available, and provides a full, velvety, well-textured skin. However, its disadvantages lie in the fact that the percentage of takes is relatively low; it can only be cut in limited amounts and does poorly in the presence of infection. It is cut to accurate pattern or slightly larger to allow for a small amount of shrinkage. Fat and other subcutaneous tissues are cut cleanly away from the corium, and it is sutured accurately in position with numerous interrupted "plastasutes" and secured with a firm pressure dressing. In short, when it takes it is excellent.

When body contour is lost tissue in greater amounts than provided by the free skin grafts becomes necessary. Then one attempts to graft greater bulks of tissue by providing them with a modified blood supply during the course of transfer. This is done by using one of the several types of pedicle flaps, the pedicle being

the part provided to maintain the graft alive during the course of transfer.

The *simple pedicle flap* is one in which a piece of skin and subcutaneous tissue is cut free on three sides, the fourth side being left as its nourishing pedicle. The piece of tissue surrounded by the three cut sides is raised and twitched into its new position, the defect being closed by direct suture or by free grafting. A simple example is the covering of the back of a hand from an abdominal flap (Fig. 2). Another example is the Abbé lip-switch operation (Fig. 3) in which a "V" of a redundant lip is cut, all but a pedicle including the inferior labial artery. This V is then switched into an incision in the upper lip, still attached by the pedicle. At the end of 10 days to 3 weeks the pedicle is cut. The Z-relaxing incision, recently well described by Davis and Kitlowski,¹⁰ is really a double pedicle flap. Simple pedicle flaps are used in correcting defects about the eyelids and in some of the operations for the correction of hypospadias when pedicle flaps are switched in from the scrotum.

The *delayed pedicle flap* (Fig. 4) is a further modification of the former, and its use is entirely at the discretion of the surgeon. If he feels that the bulk of tissue he is about to transfer is too great for nourishment from the available pedicle he will cut the three sides, raise it and suture it back in the same place, thus coaxing blood supply in along the line of the pedicle, *i.e.*, he cuts lateral blood supply and encourages longitudinal blood supply. After a period of waiting, 10 days to three weeks, the flap is again raised and switched to the desired position. The common method of rhinoplasty (Fig. 5) is the classical example of this type of flap. A delayed flap is carefully assessed and outlined on the forehead. Its sides are cut leaving a pedicle on the supraorbital vessels and it is then sewn back in position. A free thick or thin razor graft may be sewn on the under side of the flap to provide lining for the nose. After a waiting period

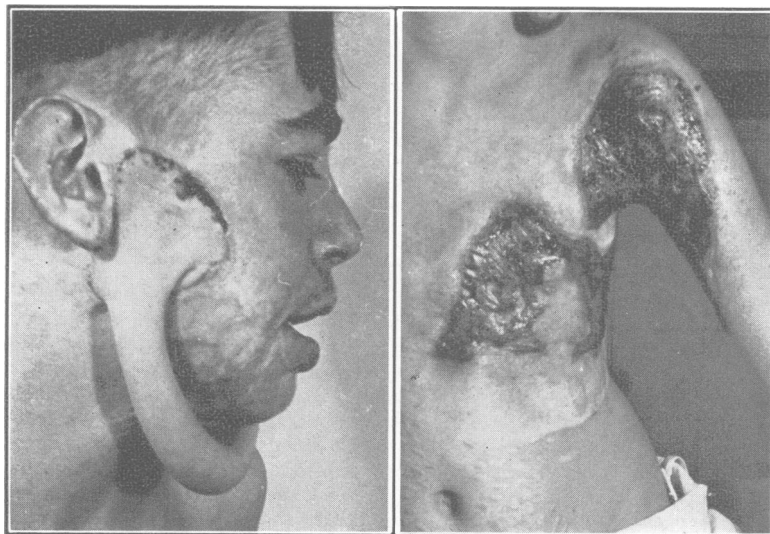


Fig. 8.—An acromipectoral tubed pedicle flap between stages of "setting in" for extensive keloid burn scar of the face, ectropion of the lower lip and a slight web scar of the neck. **Fig. 9.**—Burns of the axilla and chest. Early surfacing with thick split grafts is aimed at. As soon as the initial shock is passed one prepares the bed for grafting by alternate saline baths and dry treatment with remedial exercises during the bath. No dressings necessary. If they are used at night they are allowed to soak off in the morning bath. In this way the child loses its fear of dressings and the burned area may be quickly whipped into shape for grafting. Pinch grafts had been used on the above case with indifferent results, probably due to unsatisfactory preparation of the graft bed. Within six weeks of the institution of the saline bath routine the areas were completely covered.

the whole is raised again and switched down to its position on the nose. The defect is grafted with a thick split graft.

It is in the *tubed pedicle flap* that this principle has its greatest expression and provides a means of transporting great masses of tissue to entirely new and distant situations. This is the graft introduced by Gillies and Filatoff independently during the great war, and Gillies and his co-workers have remained its masters, extending its scope and usefulness.

In brief, an area of tissue is decided upon, usually rectangular in shape (Fig. 6), and its two sides are cut down through skin and superficial layer of deep fascia. The two ends are left as the pedicles and the mid-portions are sewn together in the form of a tube. This tube, designed for some distant and deformed part of the body has a double blood supply, each of which in the course of several weeks becomes capable of nourishing the whole tube. Then one or the other end may be detached and switched to a site closer to its destination or through the medium of arm or leg approximated to its ultimate site. Eventually one end is set in at one extremity of the deformity. At a later stage, the remaining pedicle is set in at the other end of the deformity and the intervening tube opened out and flattened into its new position.

Tubes may be raised from most parts of the body, but some sites lend themselves to better advantage than others. One endeavours to cut the tube parallel to superficial sources of blood supply rather than across them, and not to cross the mid-line. However, if one proceeds with caution and delays the tubing for one or two times, tubes can be eventually made in unfavourable sites and carried across the mid-line. Some of the common sites are (Fig. 7) (1) the side of the neck providing a good skin for nose restorations as popularized by Straith, (2) the acromiopectoral tube, an excellent one for most face work, (3) the thoracolumbar region from which long tubes can be cut and favourable approximation of the edges of the donor site obtained. Webster,¹¹ of the Presbyterian Hospital, has recently outlined in excellent fashion the advantages of this site. (4) The inguinal tube is an old standby and lends itself readily to transfer via the wrist to the face. A scapular tube may be swung nicely to the face. The author has recently tried a lumbo-ileo-femoral tube⁵ to

restore an extensive loss of jaw bone and skin of the face and neck, including the crest of the ilium in the tube for restoration of the jaw bone.

Davis and Kitlowski¹² have brought out a very helpful advance in the designing and cutting of these tubes, whereby the edges are staggered (Fig. 6), permitting closure without the bothersome triangular raw area of the original Gillies technique. The edges are marked with alternate single and double dots in methylene blue or brilliant green, thus facilitating the closure, point to point.

The donor site is sometimes bothersome. In small tubes this is not so, as the edges can be brought together with a moderate amount of undermining. In the larger tubes extensive undermining and even relaxing incisions may be necessary, and then closure may not be possible, it being necessary to resort to free skin grafts. Webster¹¹ describes a nice technique for effecting closure by placing numerous interrupted black silk sutures through the superficial layers of deep fascia to draw the edges of the donor site together. If this and relaxing incisions fail free skin grafting will probably be necessary.

CONCLUSIONS

There are many different types or variations of skin graft, each with its indication.

The thick split graft is the most useful free graft.

Improvements in instruments and technique have been brought out.

The delayed pedicle graft has a wide application.

Advances have been made in the design of tubed pedicle grafts.

REFERENCES

1. SAMMIS, G. F.: A new method for transfer of full-thickness skin: grille graft, *Am. J. Surg.*, 1937, 36: 46.
2. DRAGSTEDT, L. R. AND WILSON, H.: Modified sieve graft; full thickness graft for covering large defects, *Surg., Gyn. & Obst.*, 1937, 65: 104.
3. BLAIR, V. P. AND BROWN, J. B.: The use and uses of large split skin grafts of intermediate thickness, *Surg., Gyn. & Obst.*, 1929, 49: 82.
4. BROWN, J. B.: Covering of raw surfaces, *Internat. Abstr. Surg.*, 1938, 67: 106.
5. BROWN, J. B.: Restoration of entire skin of penis, *Surg., Gyn. & Obst.*, 1937, 65: 362.
6. BLAIR, V. P. AND BYARS, L. T.: Treatment of wounds resulting from deep burns, *J. Am. M. Ass.*, 1938, 110: 1802.
7. BROWN, J. B., BLAIR, V. P. AND BYARS, L. T.: Ulceration of lower extremities and skin grafts, *Am. J. Surg.*, 1939, 43: 452.
8. BROWN, J. B.: Surface defects of hand, *Am. J. Surg.*, 1939, 46: 690.
9. PADGETT, E. C.: Calibrated intermediate skin grafts, *Surg., Gyn. & Obst.*, 1939, 69: 779.
10. DAVIS, J. S. AND KITLOWSKI, E. A.: Theory and practical use of z-incision for relief of scar contractures, *Ann. Surg.*, 1939, 109: 1001.
11. WEBSTER, J. P.: Thoraco-epigastric tubed pedicles, *S. Clin. N. Am.*, 1937, 17: 145.
12. DAVIS, J. S. AND KITLOWSKI, E. A.: Method of tubed flap formation, *South. M. J.*, 1936, 29: 1169.